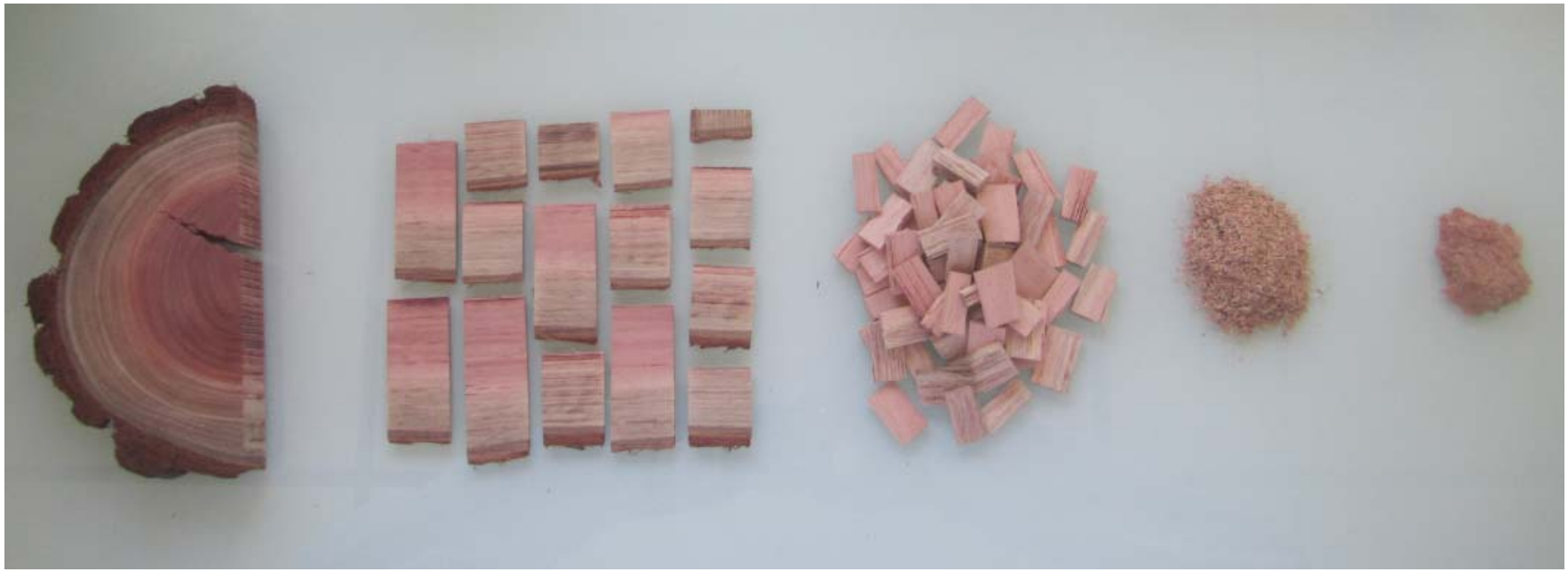
Imagerie hyperspectrale et chimie du bois (stress hydrique et minéral)

PIRES FRANCO Mariana, GORRETTA Nathalie, VIDAL Cristiane, PASQUINI Celio, TOMAZELLO FILHO Mario, ROGER Jean-Michel, CHAIX Gilles

Le bois dans tous ses états



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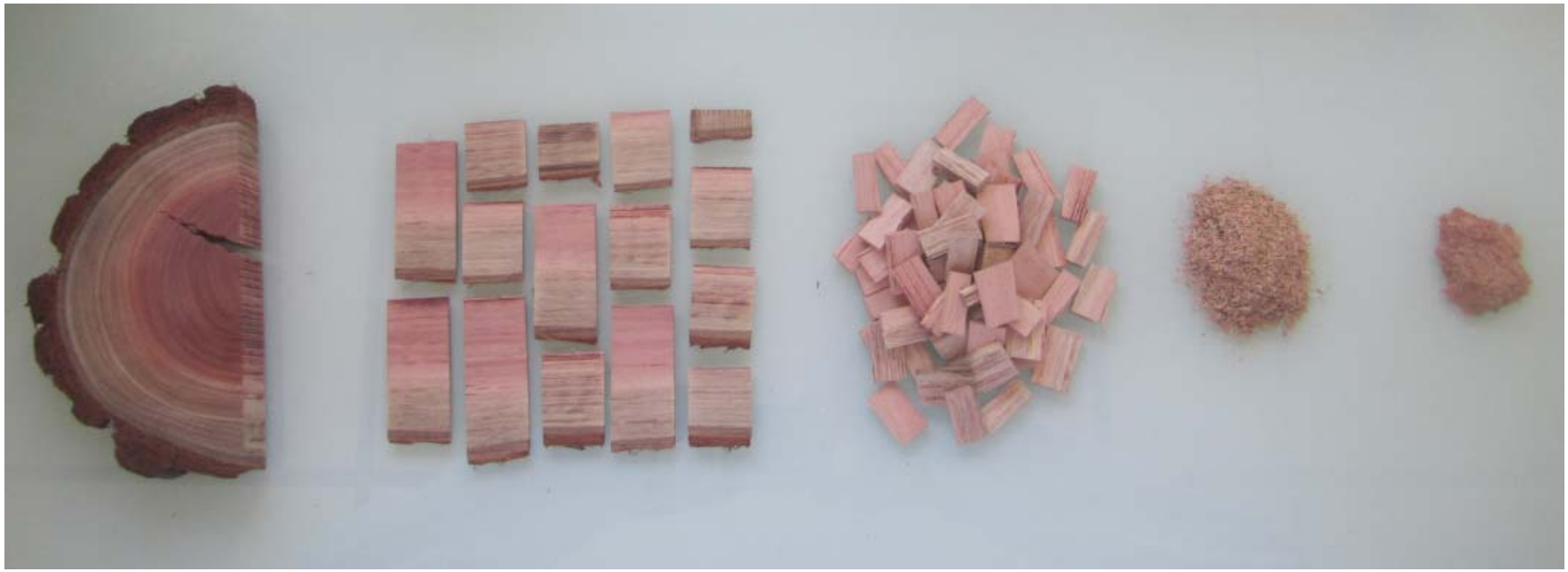
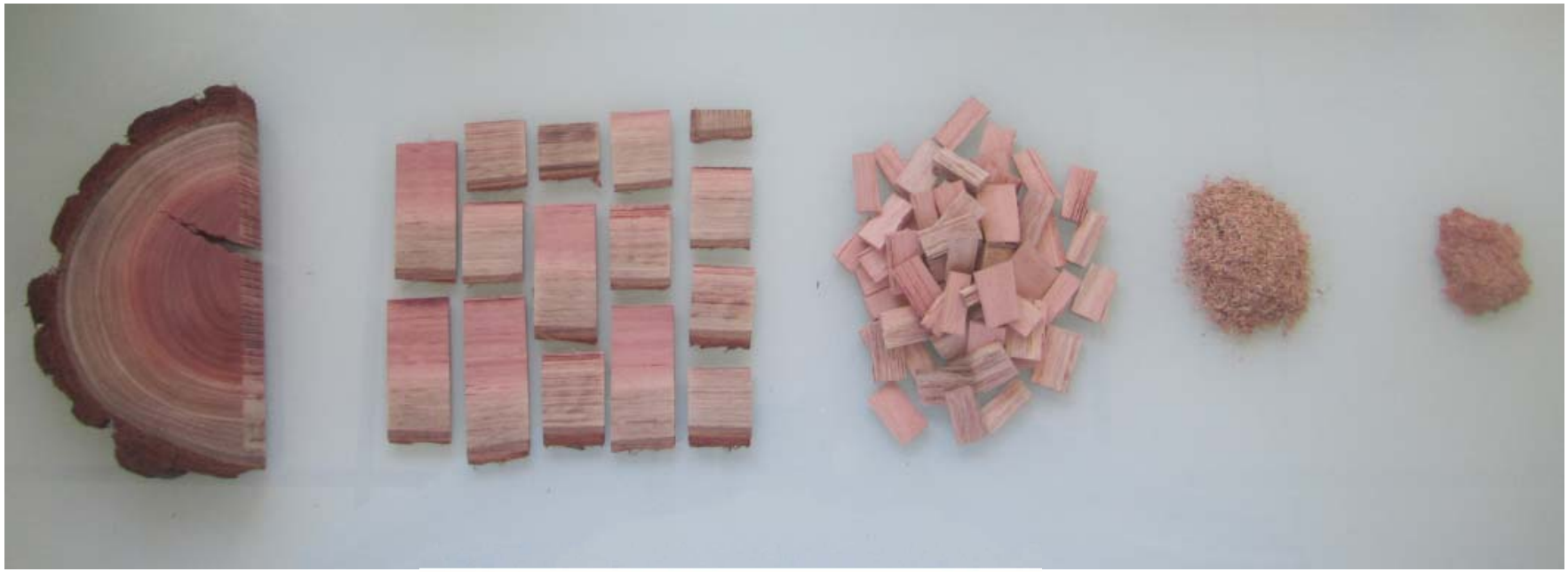
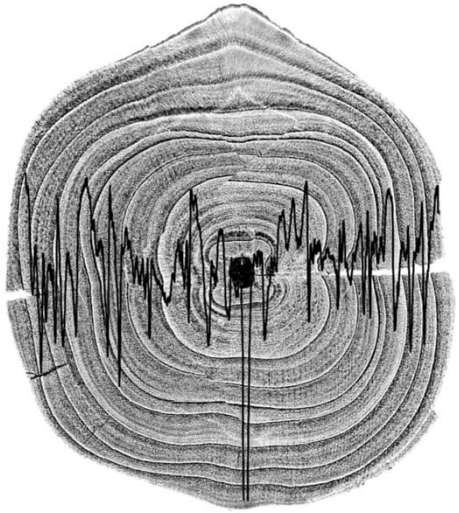


Visual observations, anatomy

Le bois enregistre les variations environnementales durant la croissance de l'arbre

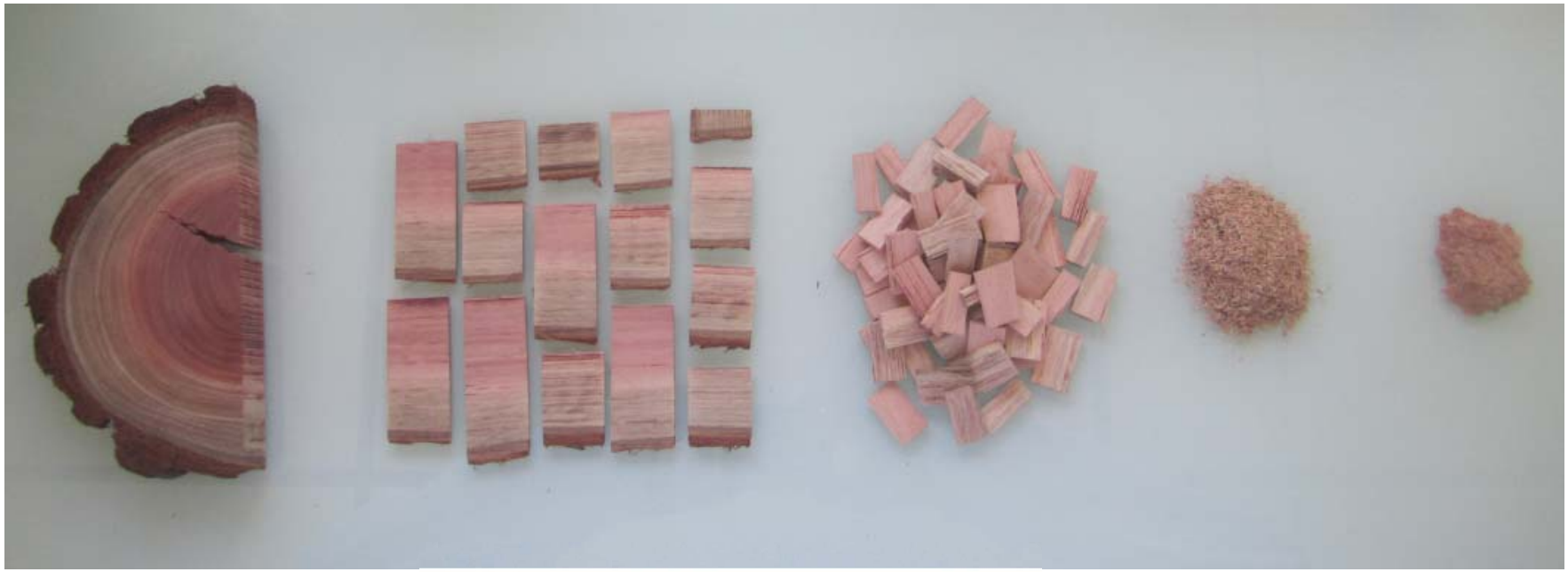


Visual observations, anatomy

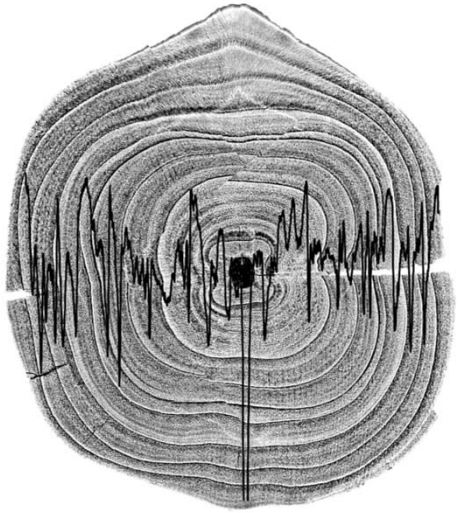


Density

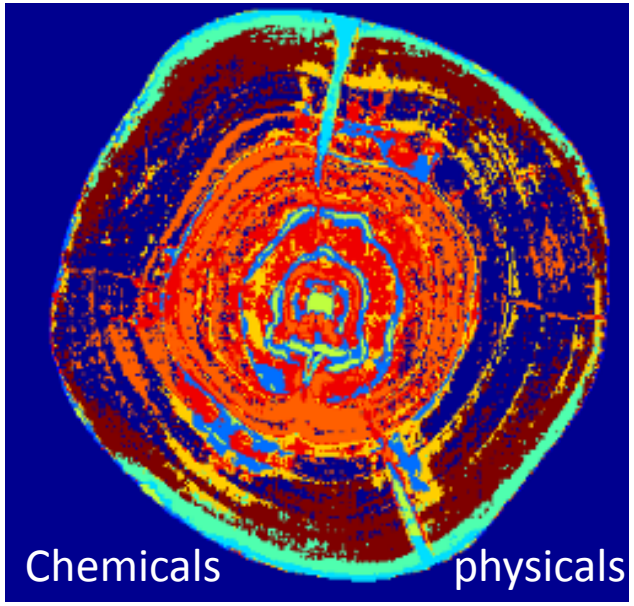
Le bois enregistre les variations environnementales durant la croissance de l'arbre



Visual observations, anatomy



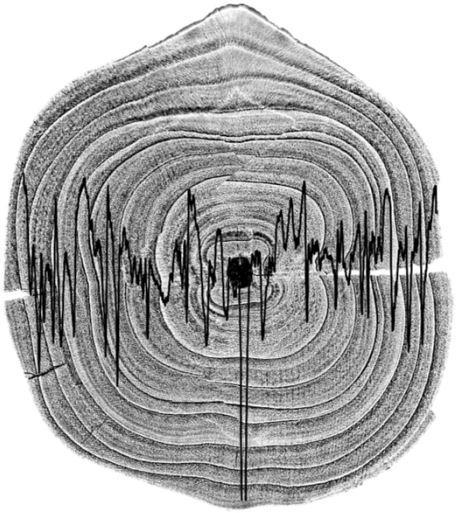
Density



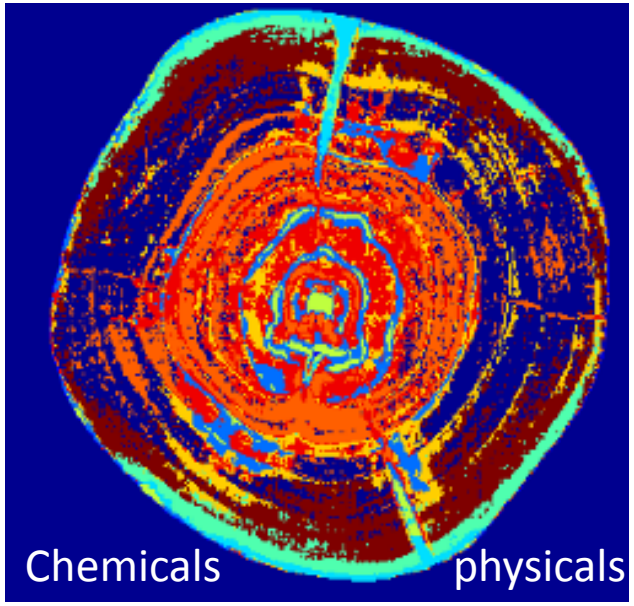
Le bois enregistre les variations environnementales durant la croissance de l'arbre

Dendrochronologie
Dendroécologie
…..

Visual observations, anatomy



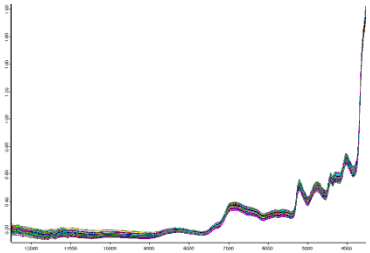
Density



Spectroscopie proche infrarouge

Etablissement de modèle de prédiction

Sample set



$$Y = \begin{pmatrix} y_1 \\ . \\ . \\ . \\ y_n \end{pmatrix}$$

$$X = \begin{pmatrix} x_{11} & \dots & x_{1v} \\ . & & . \\ . & & . \\ . & & . \\ x_{n1} & \dots & x_{nv} \end{pmatrix}$$

PLS Regression

Prediction Equation

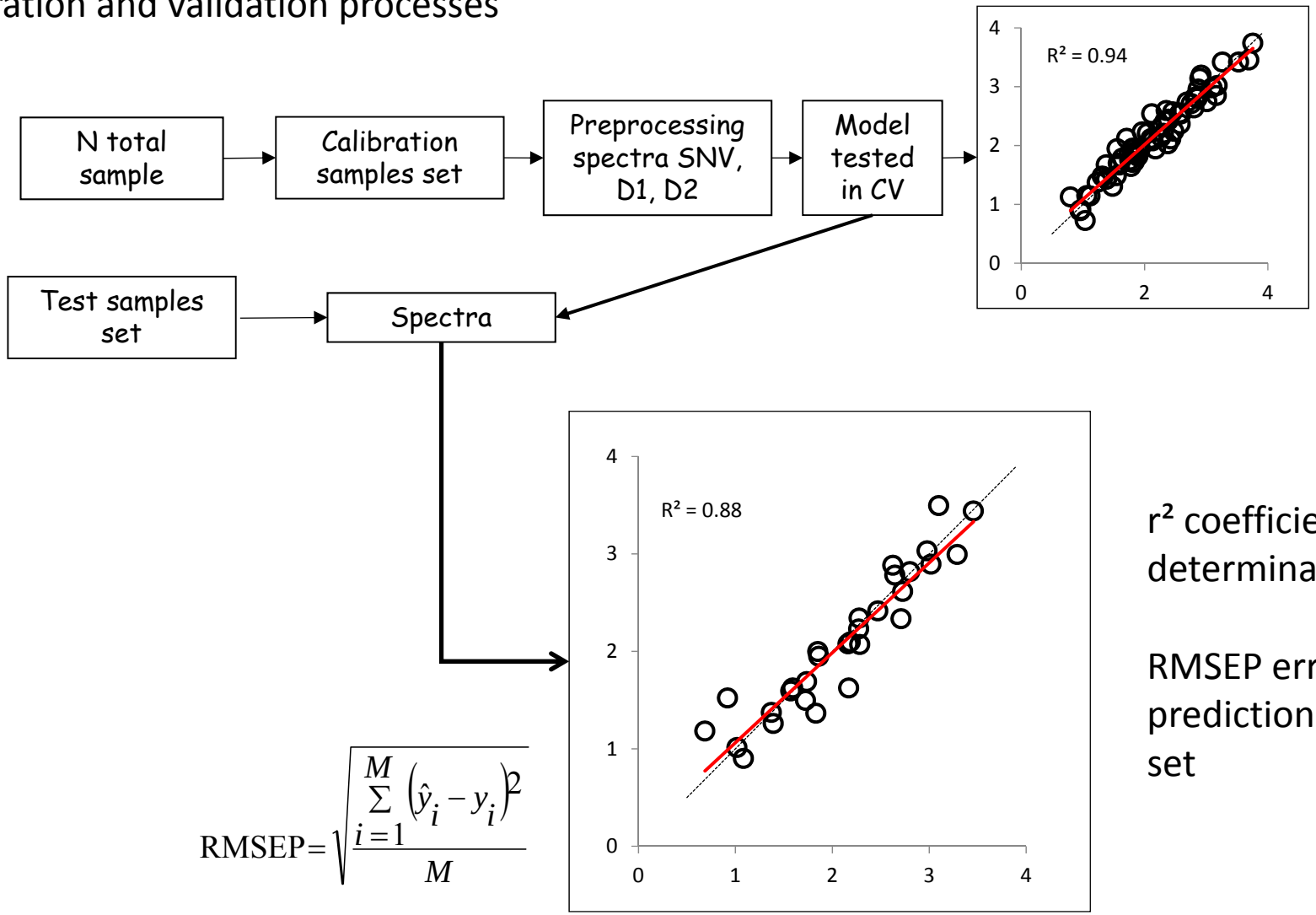
$$Y = \sum x_v \beta_v + \varepsilon$$

Spectroscopie proche infrarouge

Etablissemment de modèle de prédiction

Calibration and validation processes

$$RMSECV = \sqrt{\frac{\sum_{i=1}^{N} (\hat{y}_i - y_i)^2}{N-1}}$$



$$RMSEP = \sqrt{\frac{\sum_{i=1}^{M} (\hat{y}_i - y_i)^2}{M}}$$

r^2 coefficient of determination

RMSEP error of prediction by test set

Spectroscopie proche infrarouge (1100-2500 nm) appliquée au bois

Sélection: phénotypage, caractérisation

Chimie: Extractibles du bois, Lignine,
Cellulose, Sucres
Physique/mécanique: densité, …

Spectroscopie proche infrarouge (1100-2500 nm) appliquée au bois

Sélection: phénotypage, caractérisation

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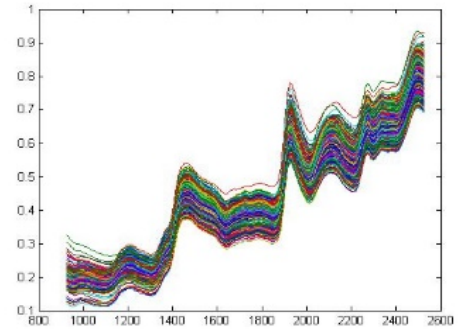
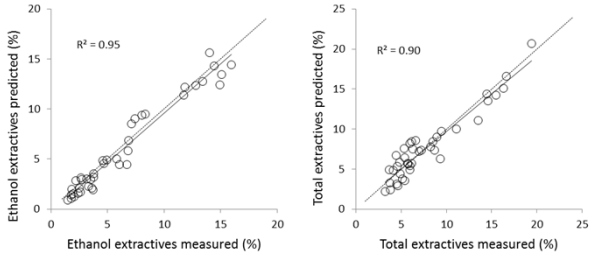
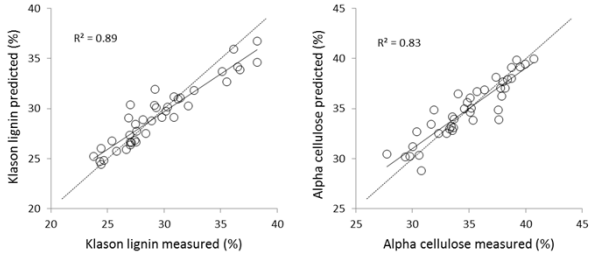
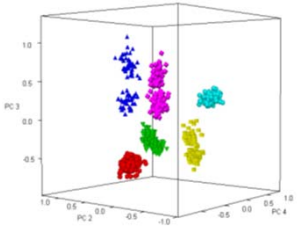
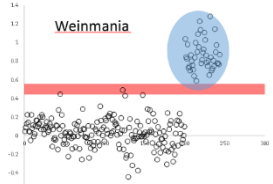
Spectroscopie proche infrarouge (1100-2500 nm) appliquée au bois











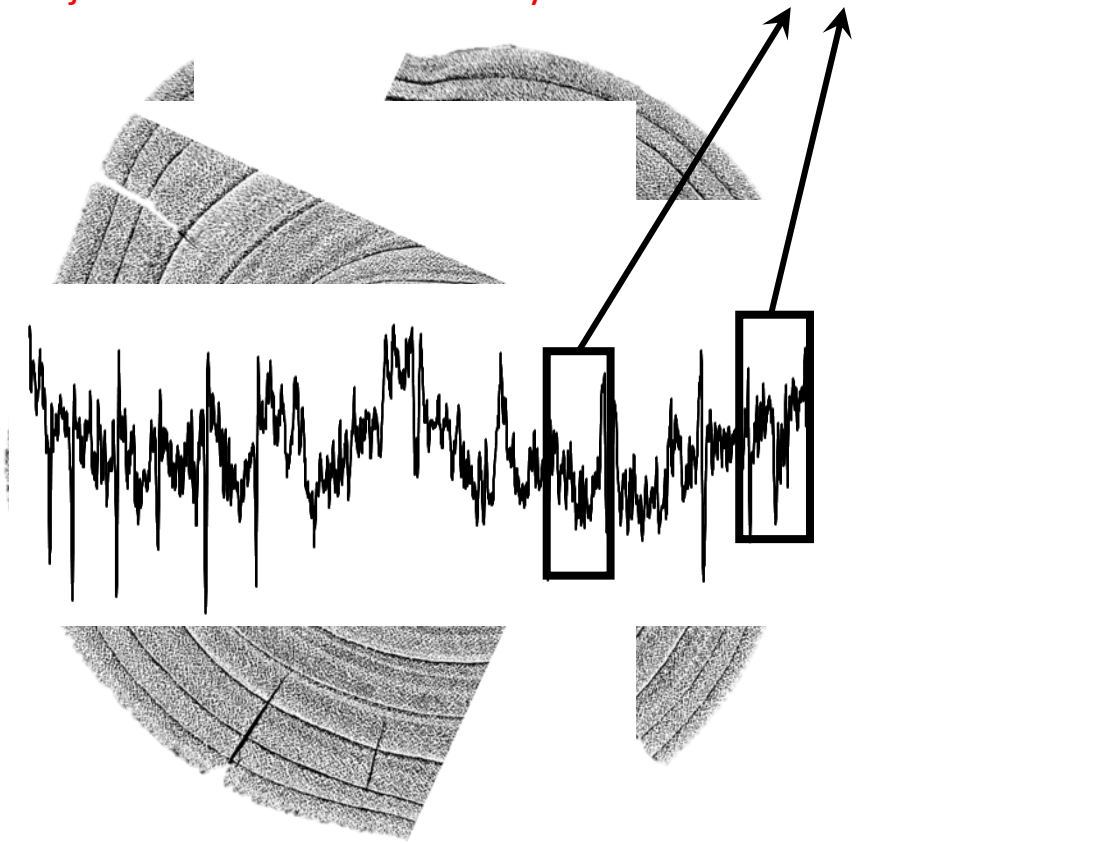
Sélection: phénotypage, caractérisation

Chimie: Extractibles du bois, Lignine, Cellulose, Sucres
Physique/mécanique: densité, …

Questions et hypothèses

Juvenil-adult correlations – Sélection précoce

Genetic and environmental effects on cambial activity
Goal: Evaluation of juvenile selection efficiency

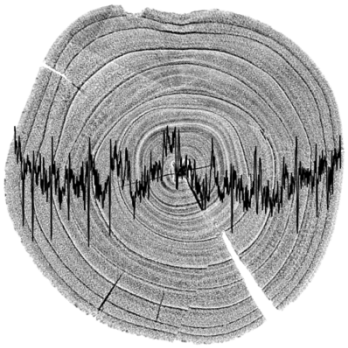
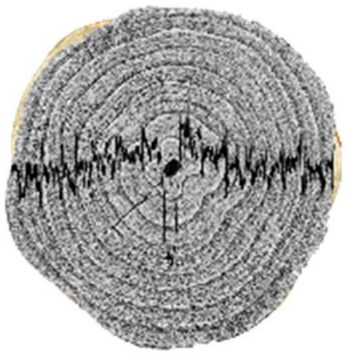
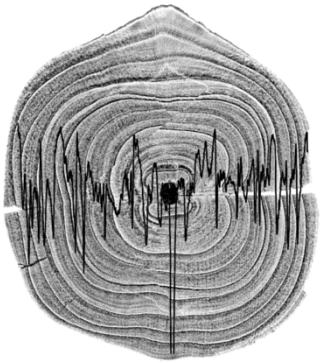
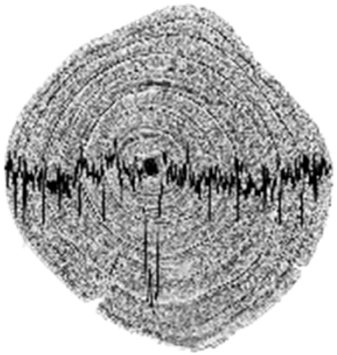


(example with micro density, but valuable for imaging focused on extractives)

Questions et hypothèses

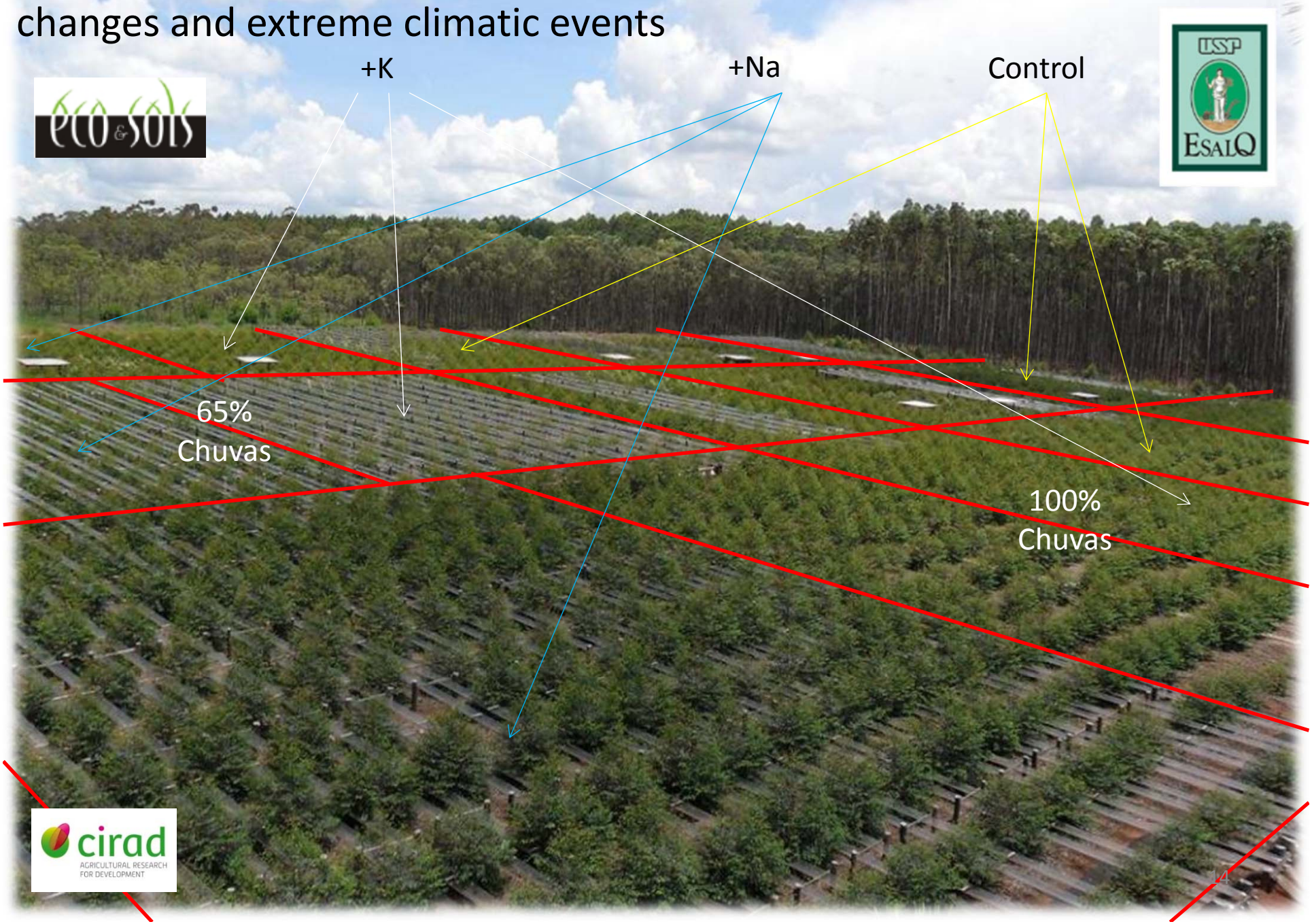
Genotype x environment interactions – plasticity/adaptation

Explore inter-annual variability with climate (rainfall, temperature) and sites
Goal: Plastic or not plastic genetic material link to climatic changes and probability of big events

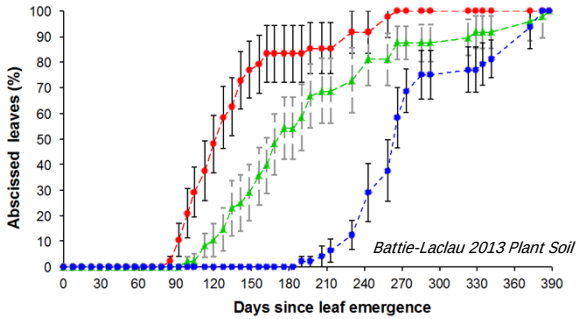
	Site 1	Site 2	
Clone A			Non plastic clone, but stable (good for homogeneity of wood but what's append during big events or marginal area?)
Clone B			Plastic clone depending of environment (good in changing environments but induce heterogeneity of material – non desirable)

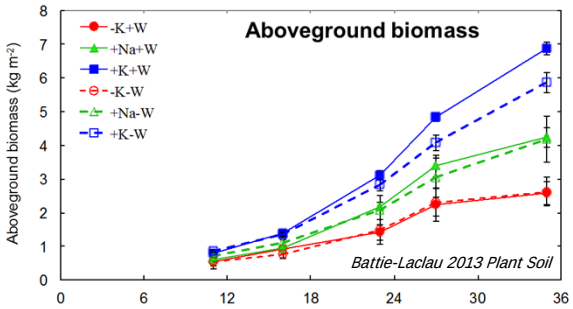
(example with micro density, but valuable for imaging focused on extractives)

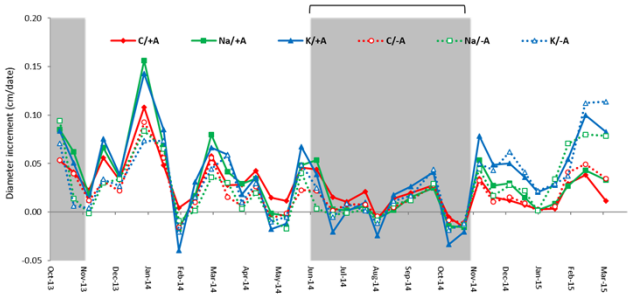
Rainfall exclusion – environment variability (ESALQ-USP, Brazil) – Climatic changes and extreme climatic events

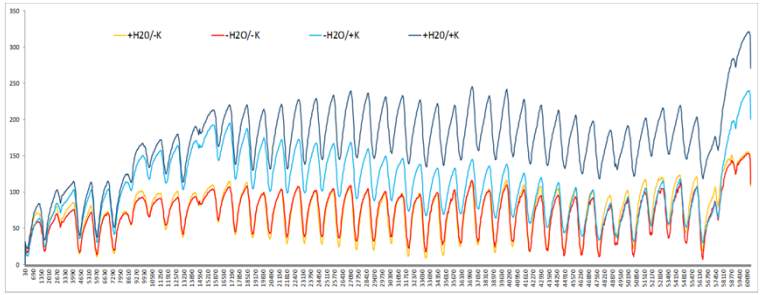


Rainfall exclusion – environment variability (ESALQ-USP, Brazil)









Impact des variations environnementales

Variabilité de la moelle à l'écorce selon les conditions de croissance

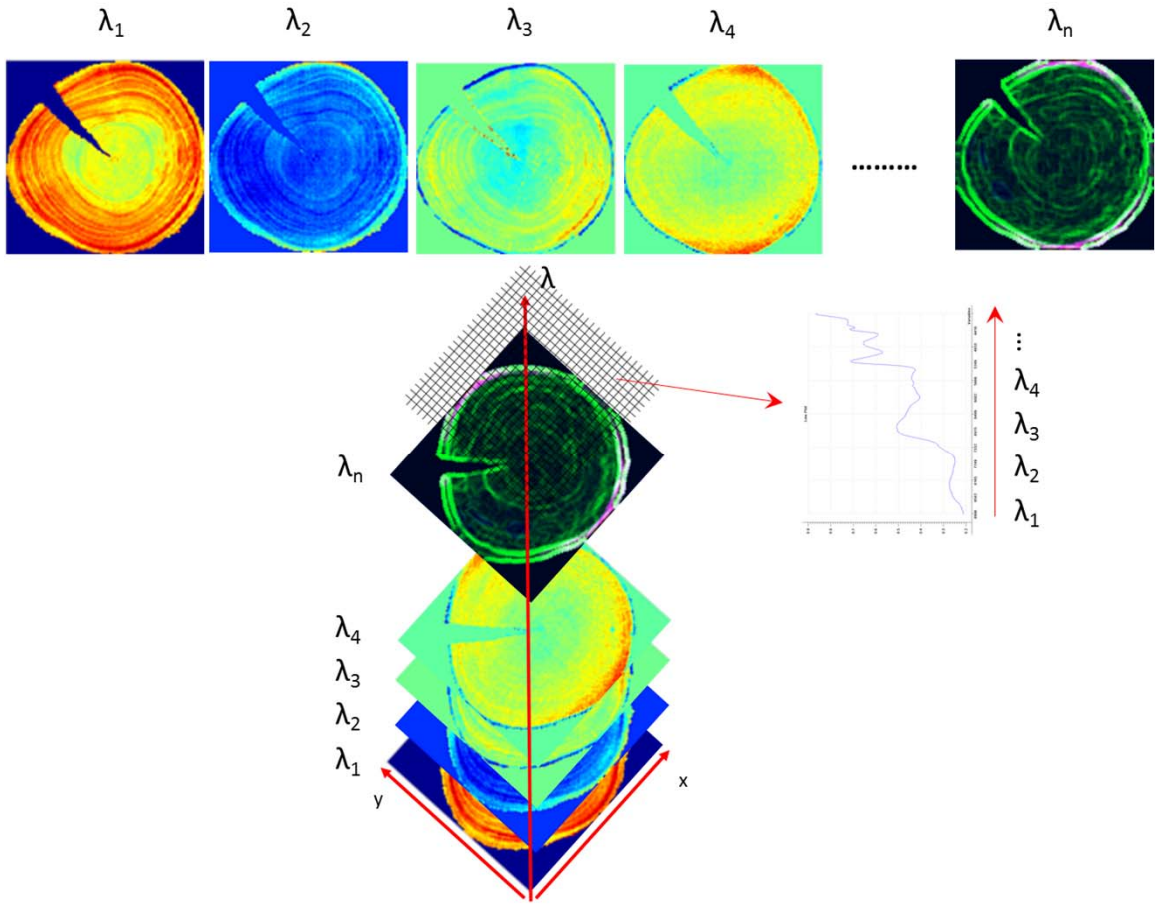
Hétérogénéité du bois plus forte quand stress hydrique, minéral ?

Conséquence sur :

- Qualité du bois (durabilité, mécanique)
- Rendement en sciage
- Séchage
- produit du bois (charbon, friabilité) ?

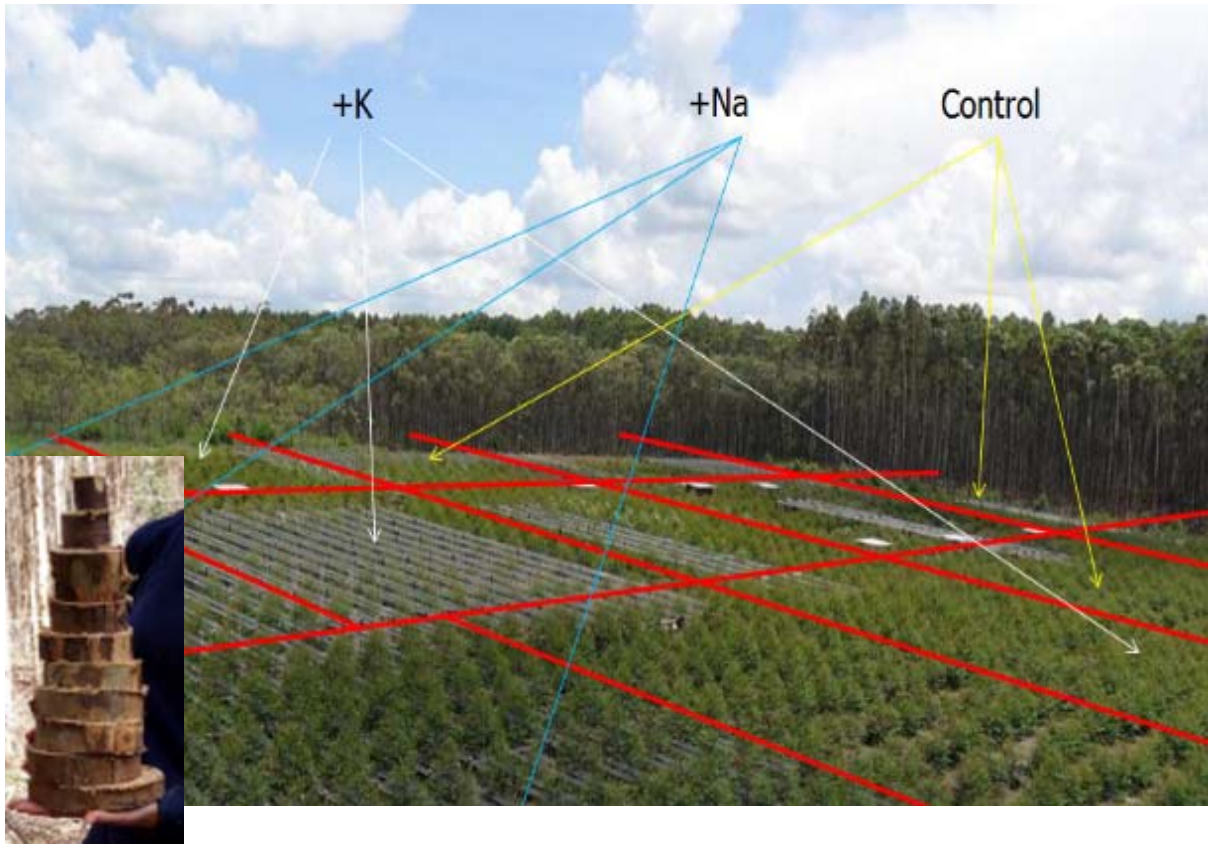
Méthode

Afin de mieux comprendre les interactions formation du bois et climat sous contraintes environnementales...



Nous proposons d'évaluer la distribution spatiale des propriétés chimiques sur les disques de bois d'arbres soumis à différentes conditions environnementales

Echantillonnage

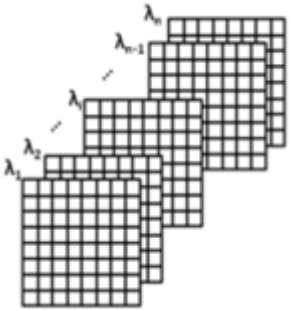


6 traitements :

100% pluie + K
100% pluie + Na
100% pluie - K et Na
65% pluie + K
65% pluie + Na
65% pluie - K et Na

- Notre étude porte sur des eucalyptus de 5 ans (15-20 m de hauteur)
- Soumis à des conditions de stress hydrique et minéral;
- Récolte de disques de bois à différentes hauteurs sur 54 arbres abattus (9 x 6 traitements).

Problématique



Total extractive content prediction

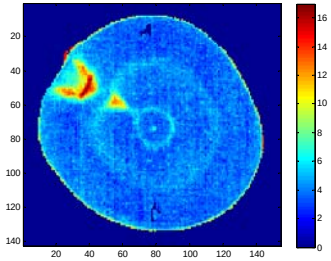
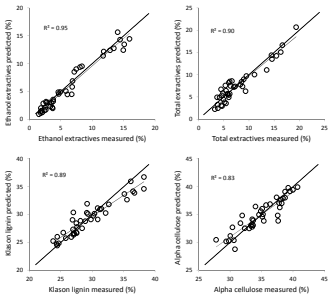


Image of total extractive content

?

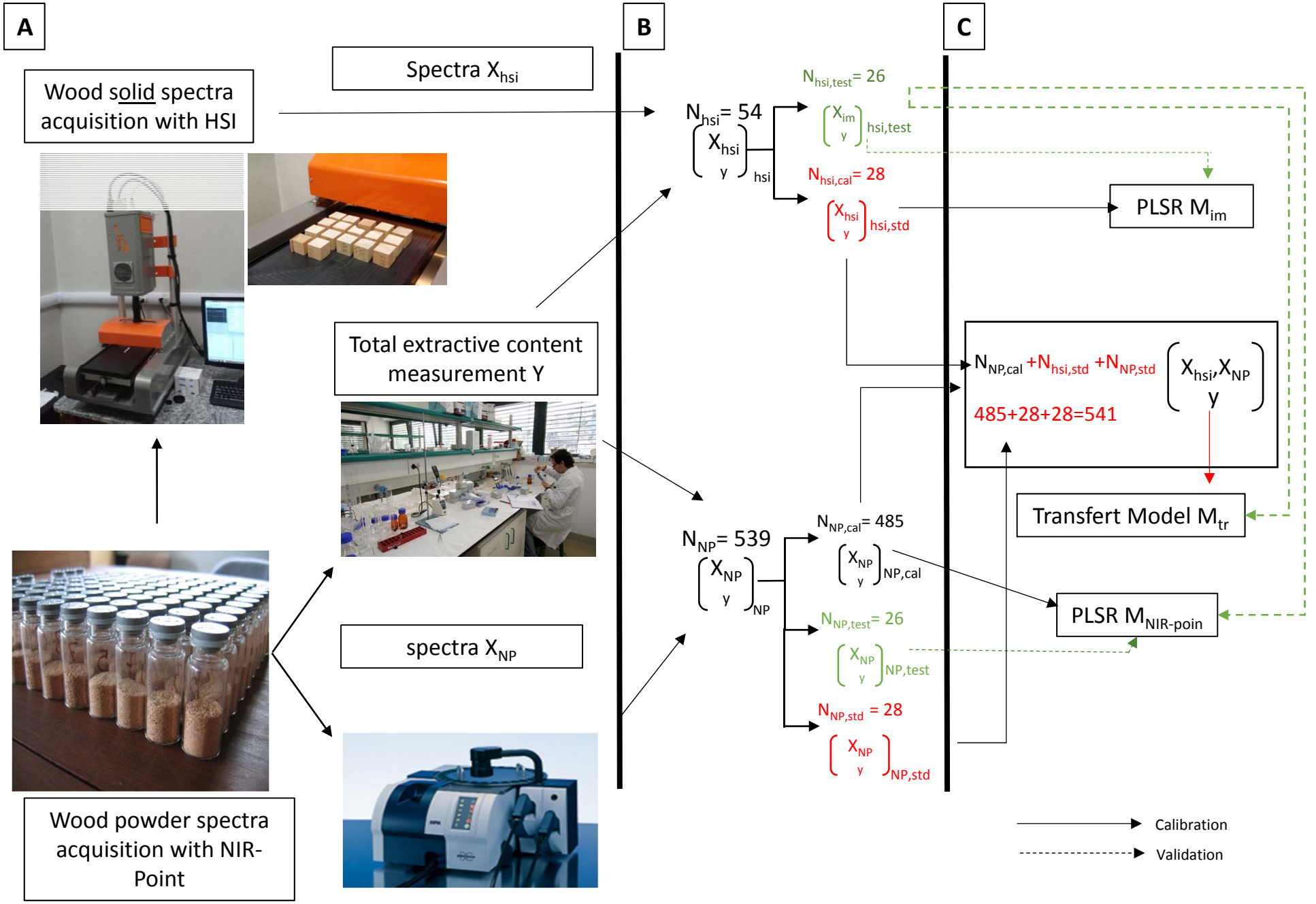


N_{vect}= 536

$$\begin{pmatrix} X_{vect} \\ y \end{pmatrix}_{vect}$$

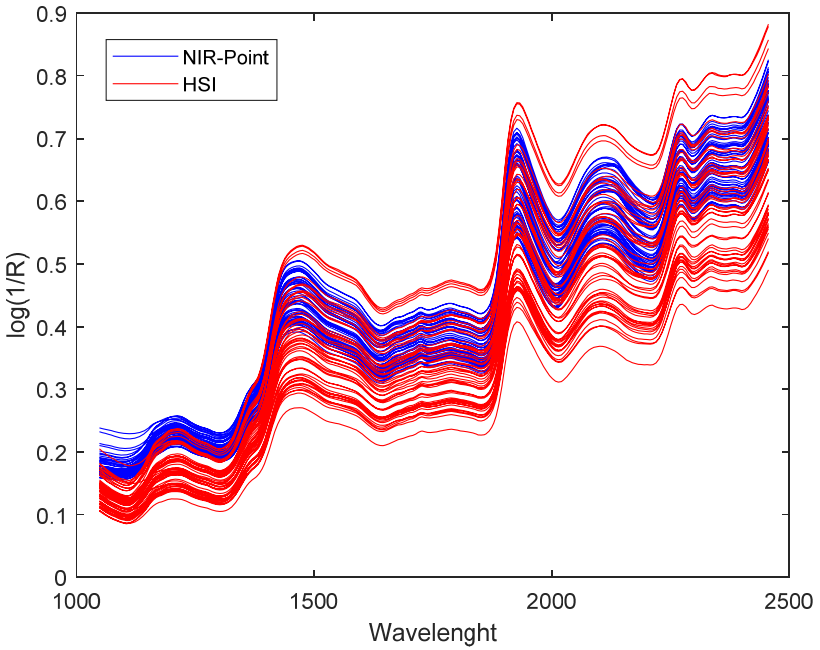
We have a bigger sample set based on grounded samples with NIR-Point

Solution proposée : transfert d'étalonnage

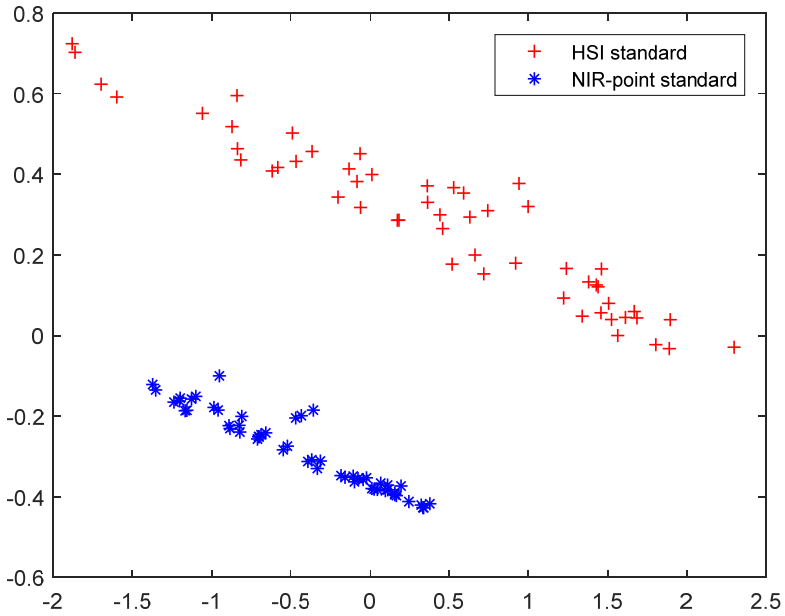


Problémtique: différence spectrale entre NIR-Point (Poudre) et HSI (solide) pour les mêmes échantillons (standards, 54 échantillons)

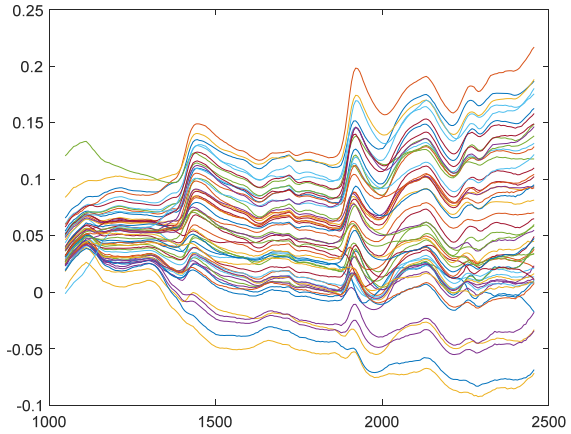
Spectres



PCA (plan PC1-87% et PC2-10%)

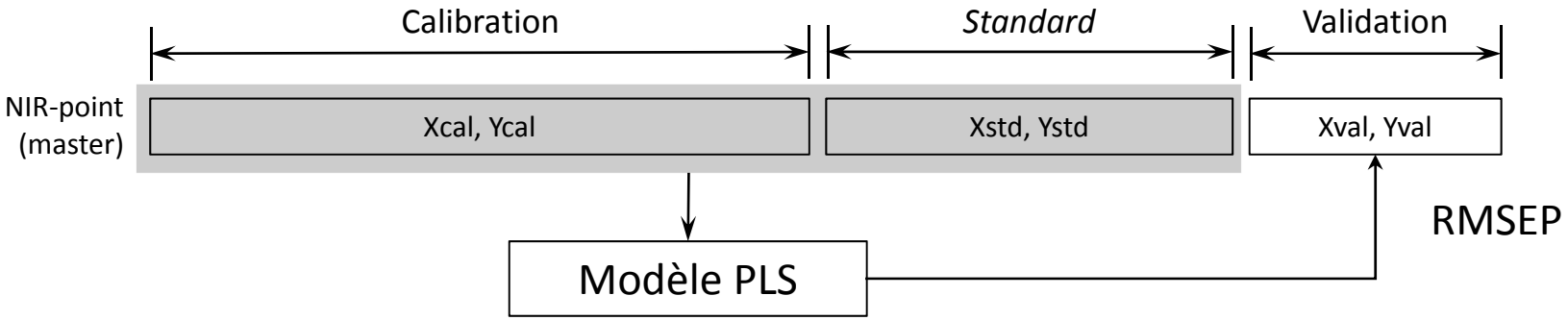


Différences spectrales



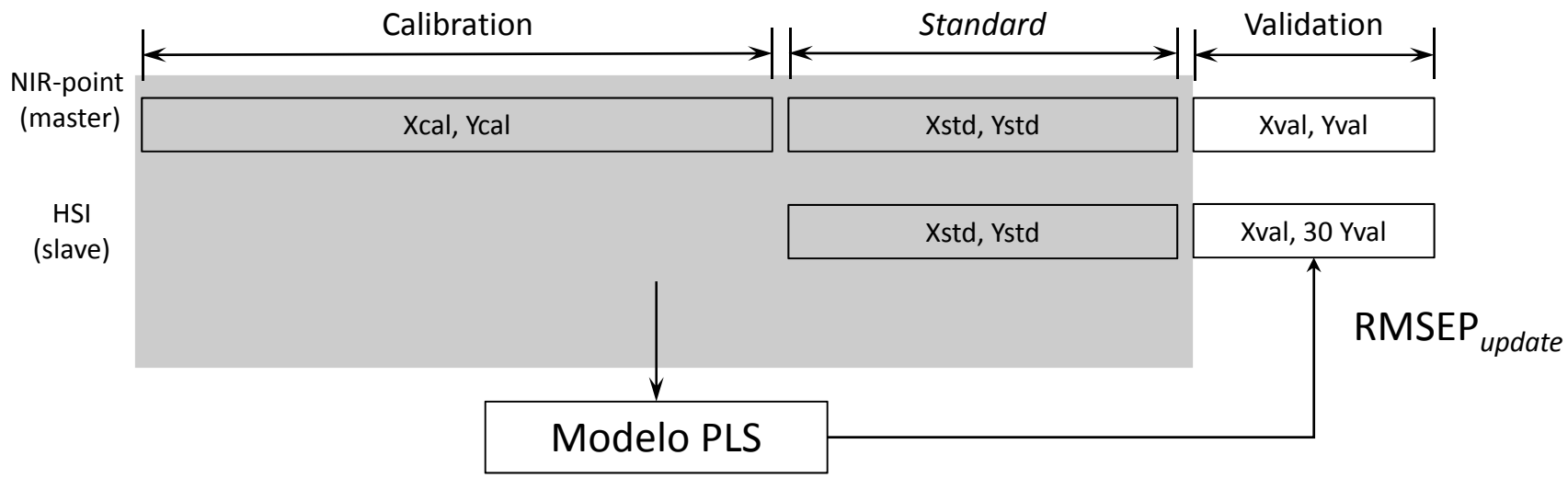
Calibration transfer

Sans transfert



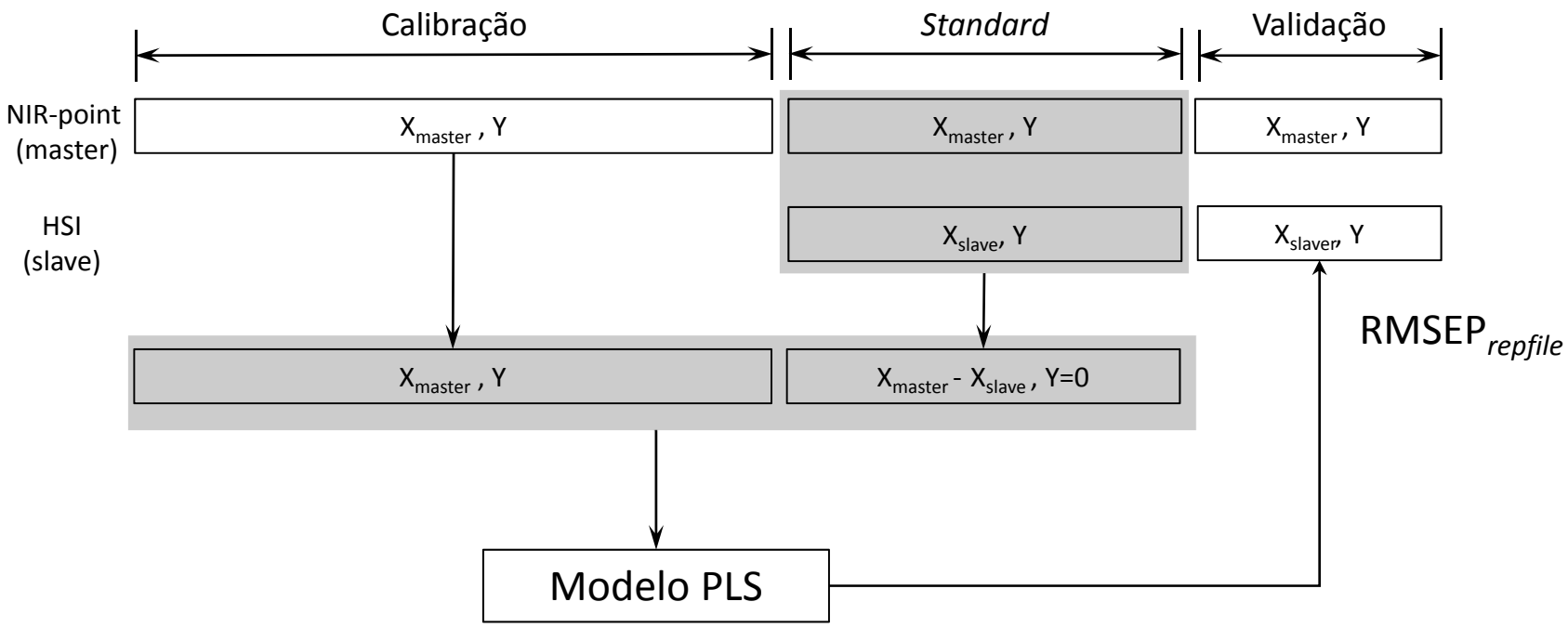
Calibration transfer

Update



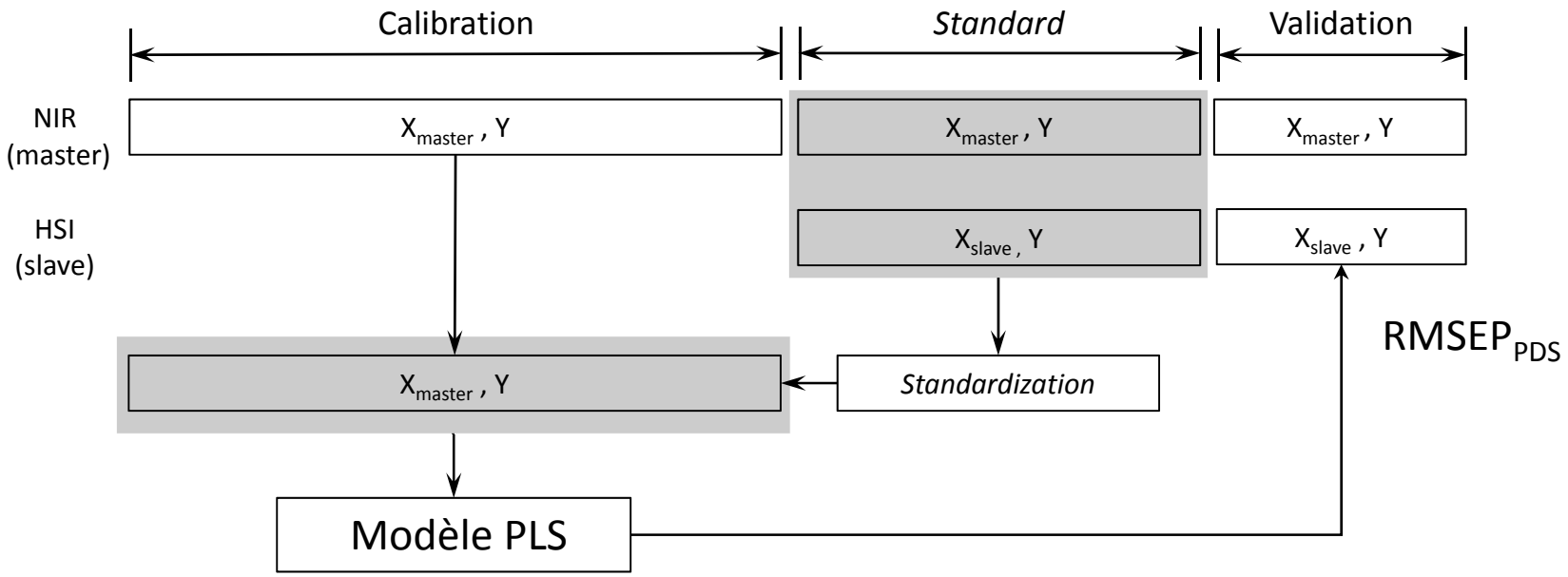
Calibration transfer

Repfile



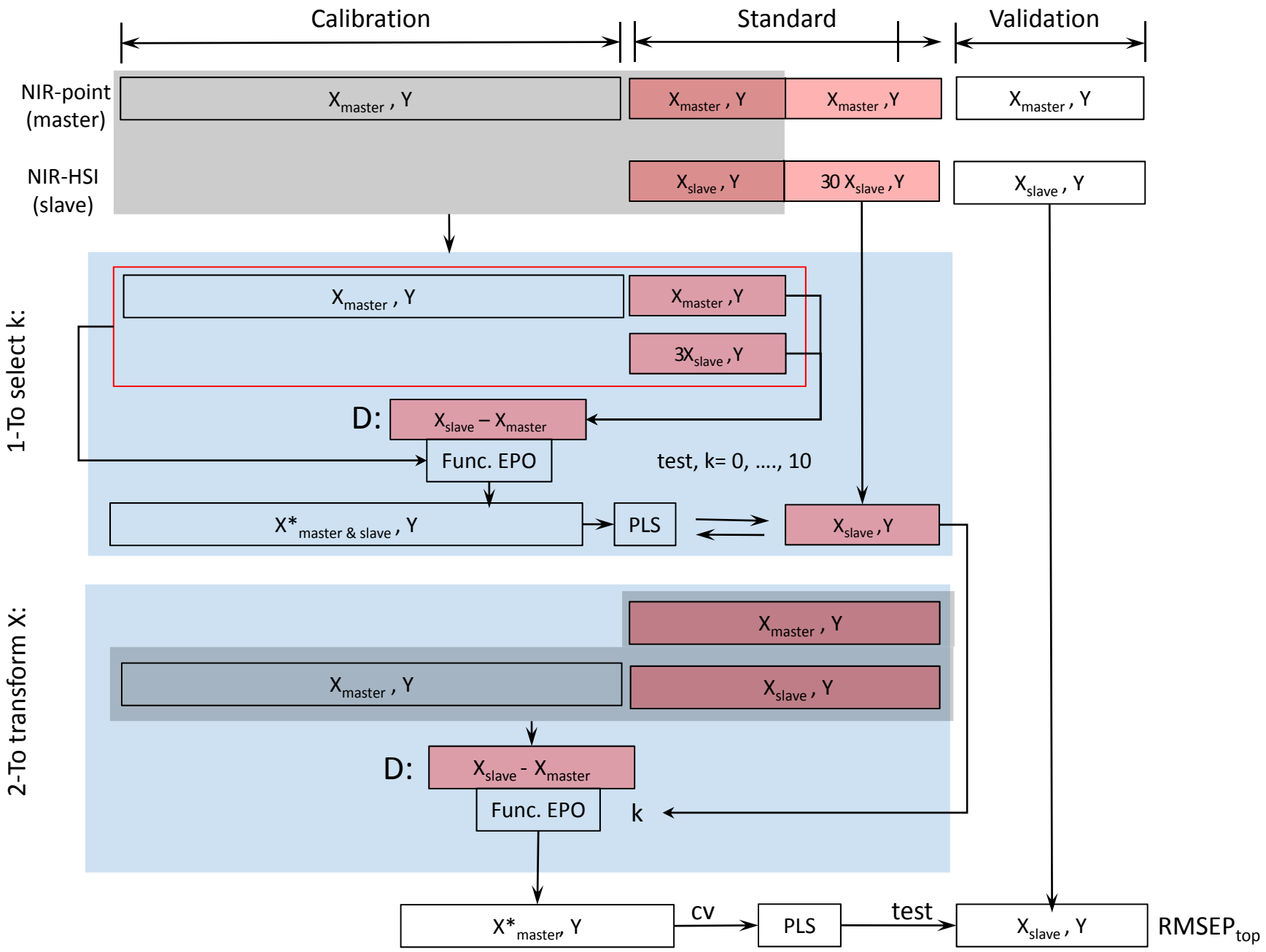
Calibration transfer

PDS piecewise direct standardization



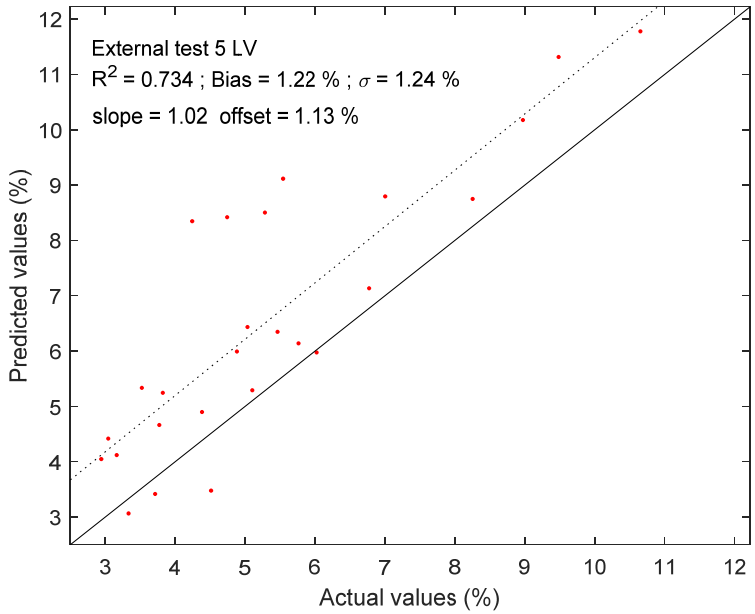
Calibration transfer

TOP: Orthogonalization

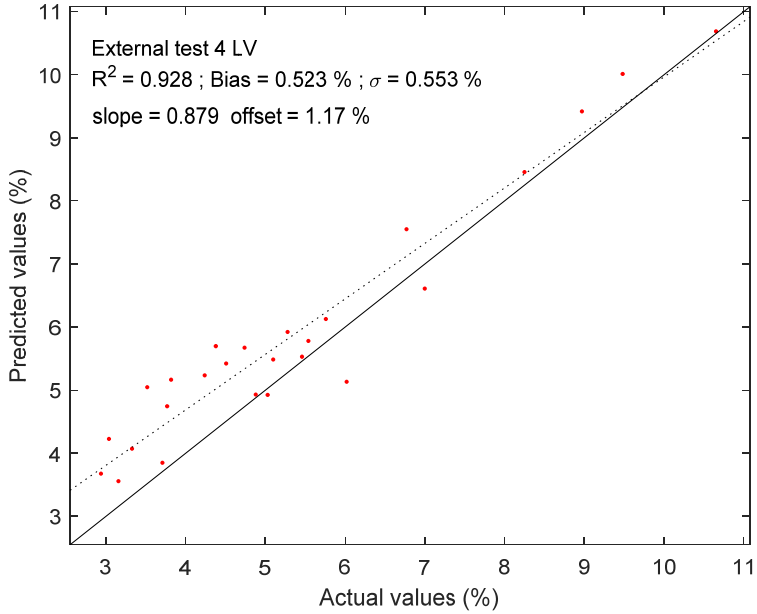


Comparaison en validation externe

Modèle NIR-point
Validation externe avec HSI



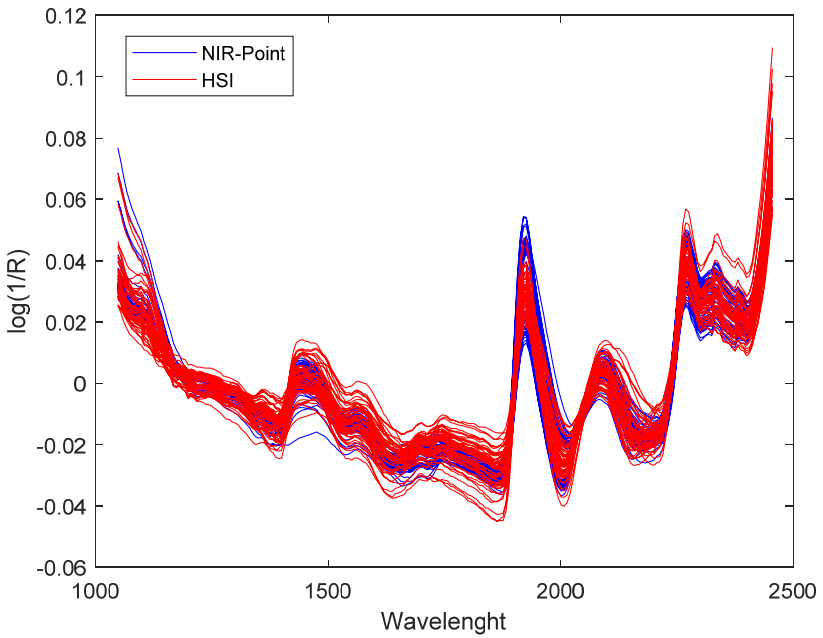
Modèle NIR-point après orthogonlisation
Validation externe avec HSI



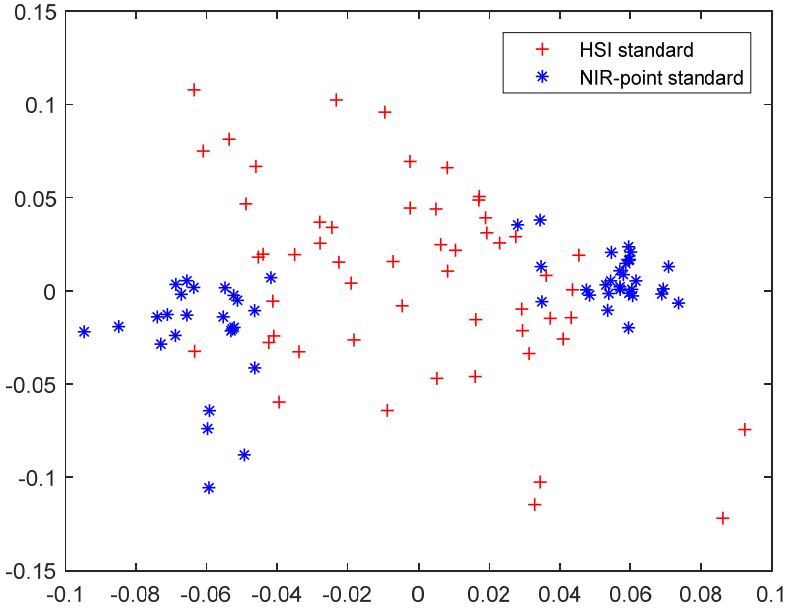
	LV	RMSEP	Slope	Biais	Offset	R²	%RMSEP	%SEL
		%		%	%		%	%
Sans transfert	5	1.24	1.02	1.22	1.13	0.734	23.1	11.6
Avec transfert (TOP)	4	0.55	0.88	0.52	1.17	0.928	10.3	

Différence spectrale entre NIR-Point (Poudre) et HSI (solide) pour les mêmes échantillons (54) après correction

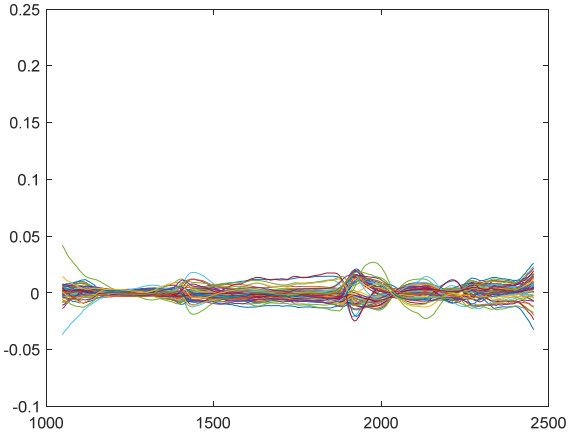
Spectres



PCA (plan PC1-42% et PC2-30%)

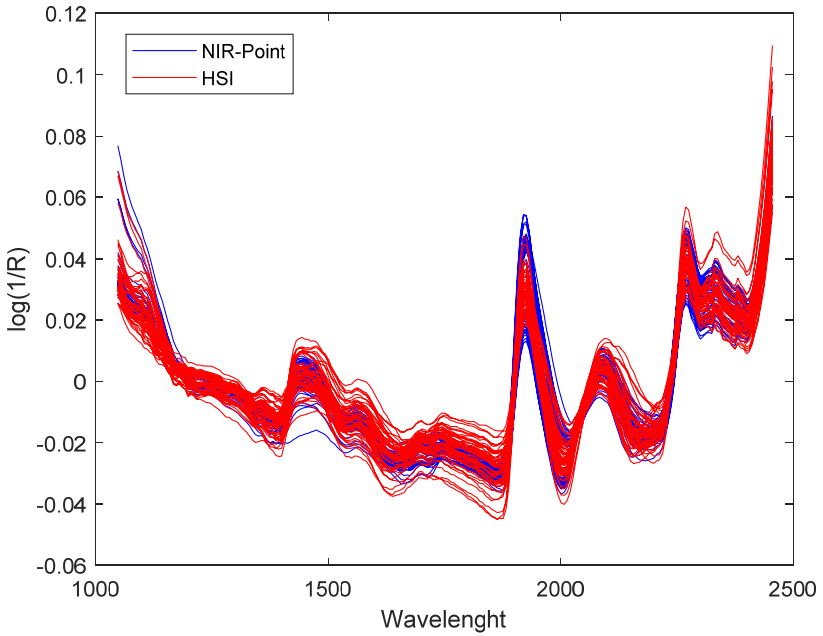


Différences spectrales

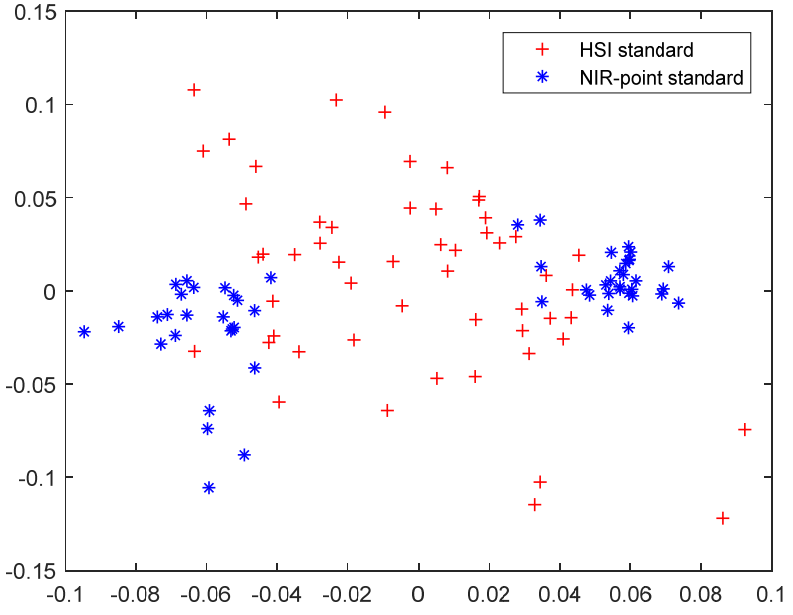


Différence spectrale entre NIR-Point (Poudre) et HSI (solide) pour les mêmes échantillons (54) après correction

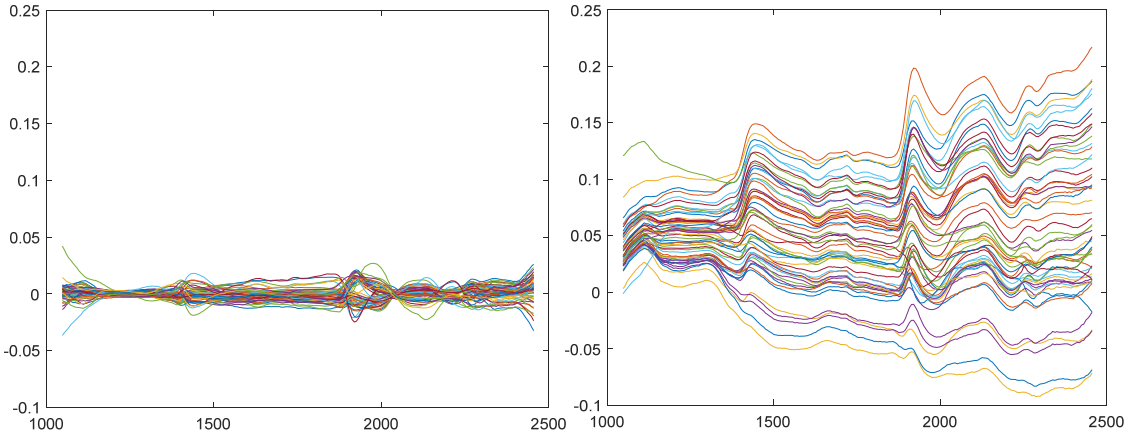
Spectres



PCA (plan PC1-42% et PC2-30%)



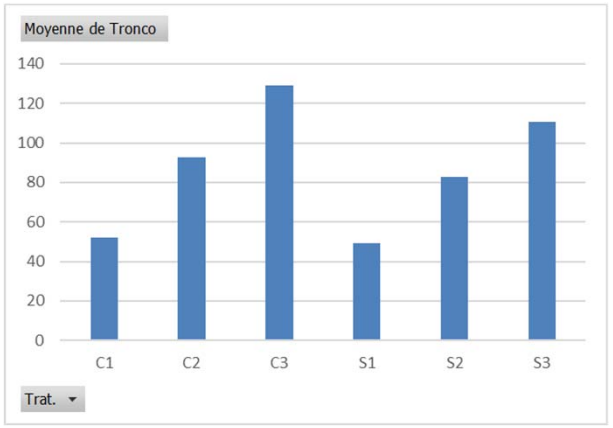
Différences spectrales



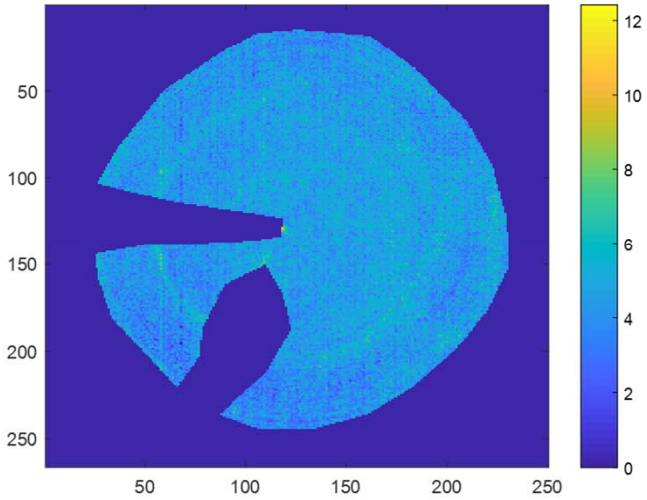
Prédiction de disques de bois / conditions de croissance

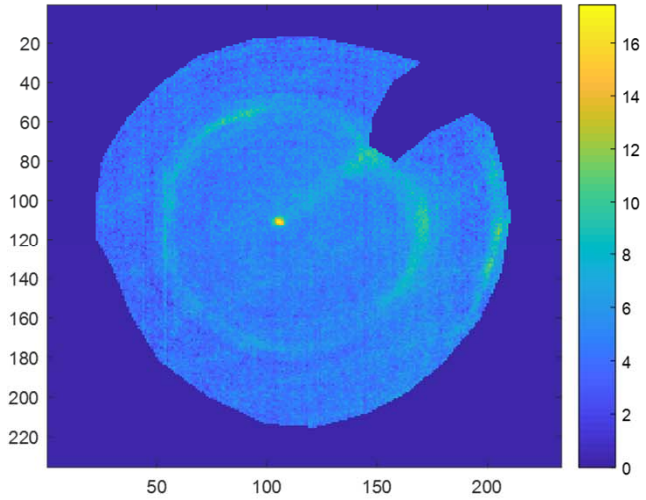
Mesure HSI sur 54 disques (9 arbres x 6 traitements)

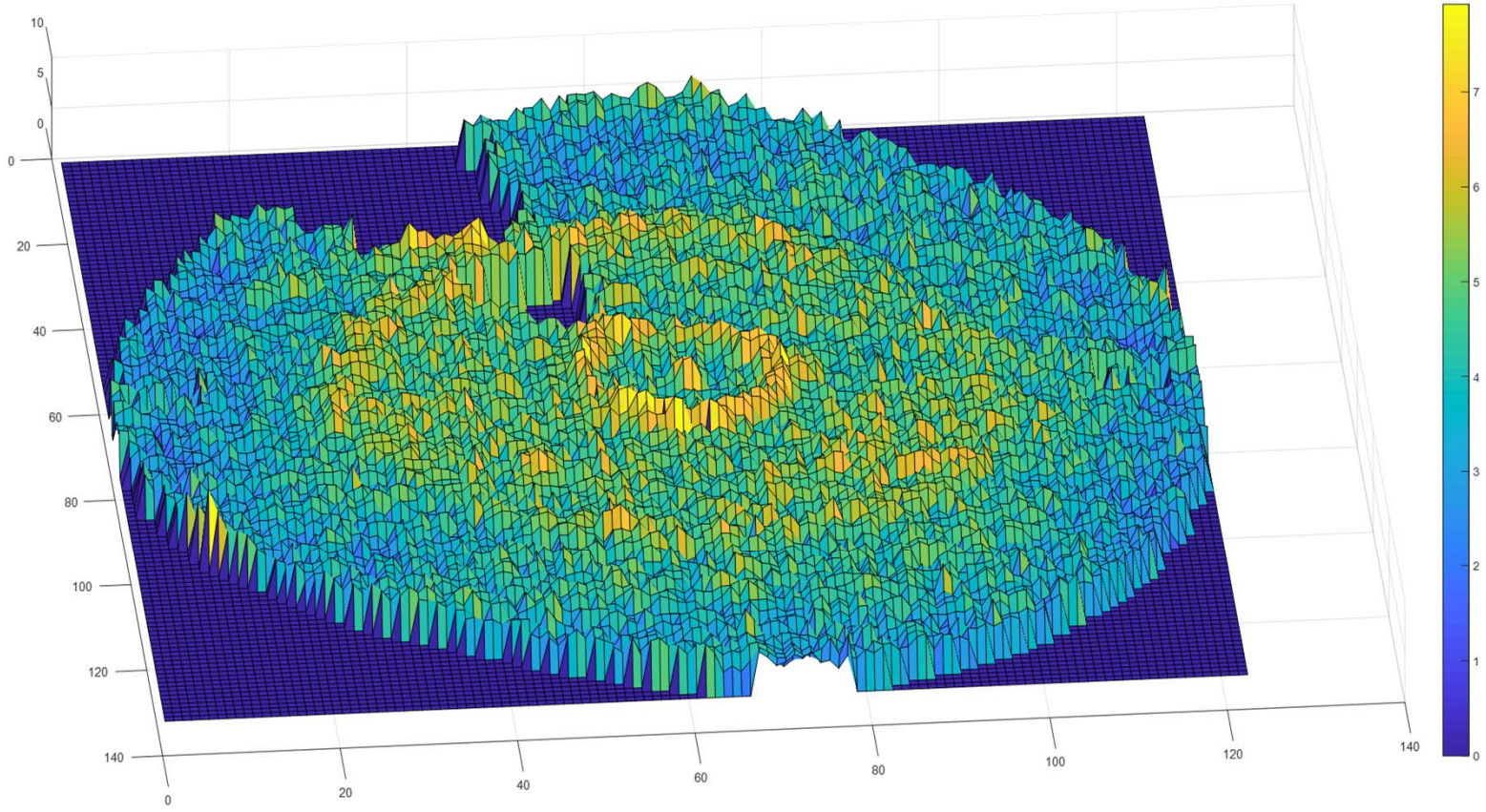
6 traitements avec un cline environnemental



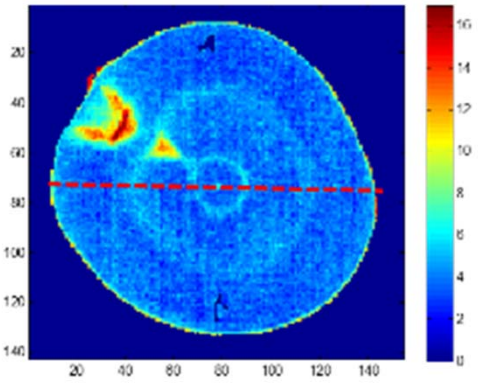
Prédiction des pixels HIS avec le modèle de transfert sélectionné

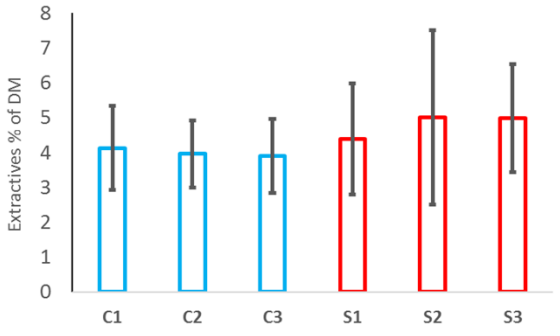




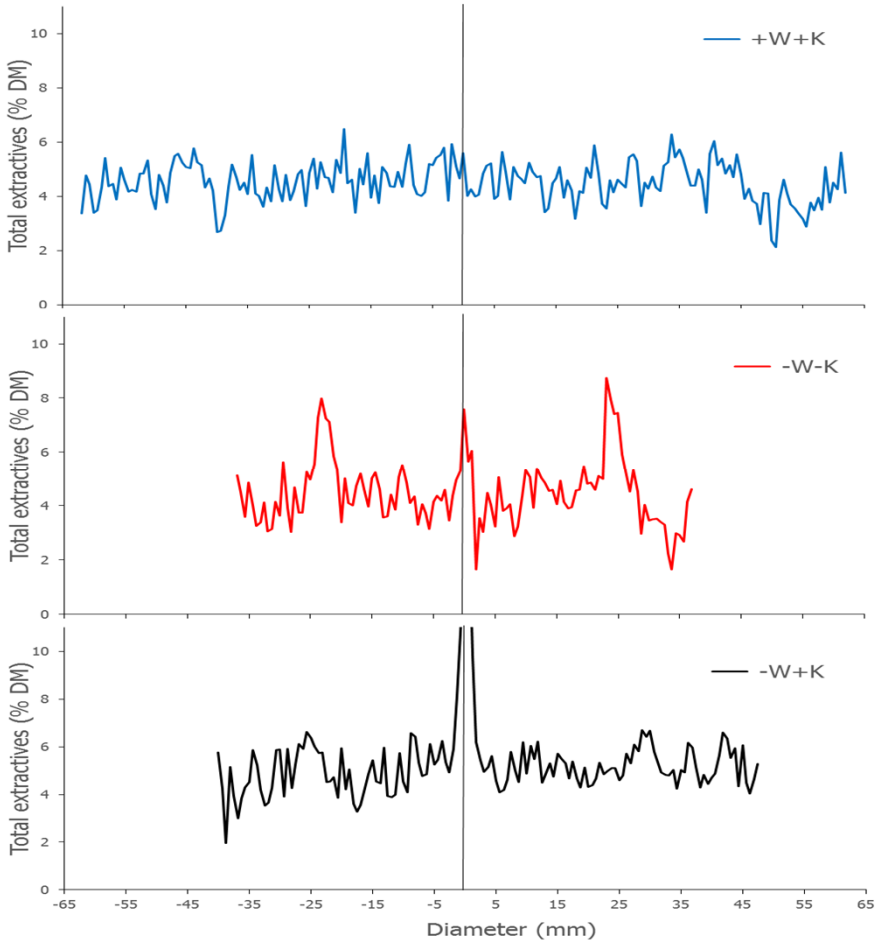

10
5
0
0
20
40
60
80
100
120
140
0
20
40
60
80
100
120
140
7
6
5
4
3
2
1
0

Exploration des images prédites





Profils de distribution du taux d'extrait

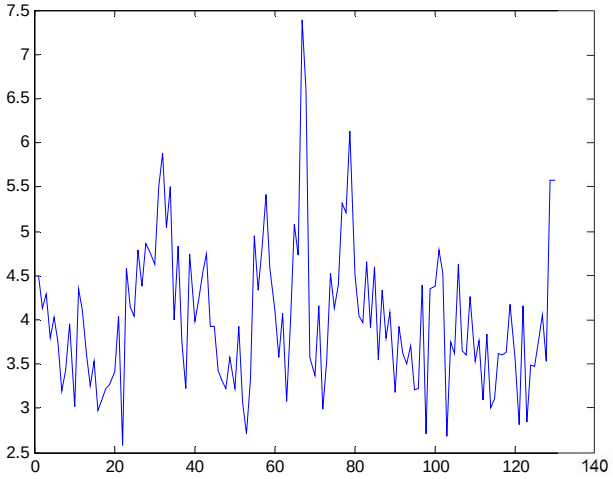


Autres propriétés chimique : Lignine, Cellulose, Densité

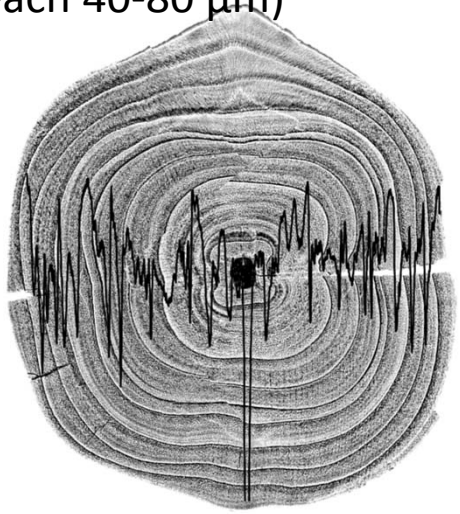
Explorer l'ensemble des images des disques à différentes hauteur des arbres

Conclusions/perspectives

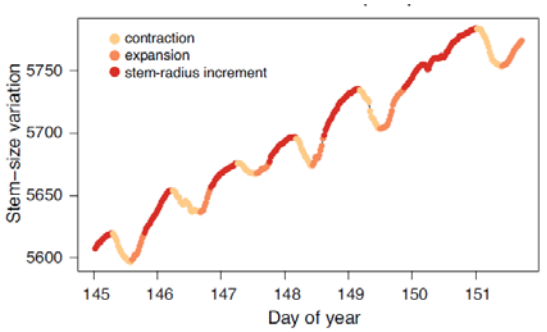
1- HIS – chemical profile (pixel size 125 µm)



2- X-Ray – density profile (each 40-80 µm)



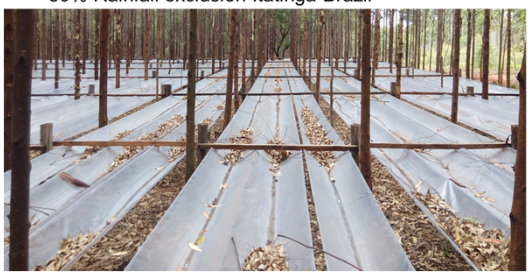
3- Secondary growth profile (each 30 minutes)



X

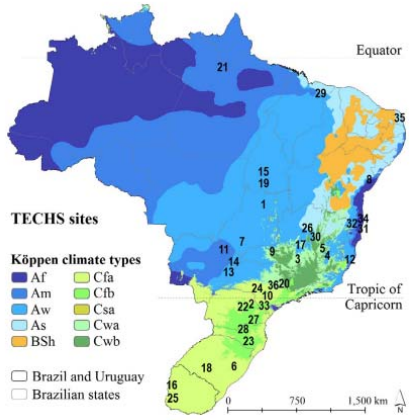
Climatic data (each 30 minutes, daily, …)

80% Rainfall exclusion Itatinga-Brazil



Environment effects on Xylogenese

Adaptation/plasticity
Extreme climatic events
Consequences on end product
Identification of proxy/markers for selection



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